Original Article

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Effects of a 12-week structured exercise program during physical education lessons on physical fitness and health-related quality of life in adolescents

Efeitos de um programa de exercício estruturado de 12 semanas, realizado durante as aulas de Educação Física, na aptidão física e qualidade de vida relacionada à saúde de adolescentes

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ABSTRACT

Introduction: Evaluating both Physical Fitness and Health-Related Quality of Life (HRQoL) in school-based interventions may offer a more comprehensive understanding of the impact of physical activity (PA) on adolescent well-being. Objective: To analyze the effects of a PA intervention on physical fitness and HRQoL in Brazilian adolescents. Methods: Students from two secondary schools participated in this randomized controlled trial and they were assigned to intervention group (n = 82) or control group (n = 84). The intervention lasted 12 weeks and was carried out in physical education classes. The structured session lasted 20 minutes each and consisted of warm-up; structured PA (muscular strength and aerobic exercises); and cool-down. Muscular fitness was assessed using handgrip and knee extension strength. Lower limb muscular power was assessed using standing long jump. Cardiorespiratory fitness (CRF) was measured with the 20m shuttle run test. HRQoL was assessed by the KIDSCREEN-10 questionnaire. Results: The sample consisted of 166 adolescents (52.5% females; 13.8 ± 0.9 years). Findings revealed significant intervention effects favorable to intervention group for the standing long jump (mean difference: 10.8 cm; 95% CI: 3.3, 18.3; n^2 0,074) and CRF (mean difference: 4.5 laps; 95% CI: 0.2, 8.2; n^2 0,054).. No significant intervention effects were found for the handgrip, knee extension strength, and health-related quality of life. Conclusion: The present 12-week intervention implemented during physical education classes was effective in improving adolescents' CRF and lower-body muscular fitness. Therefore, exercise sessions performed in 20-minute, twice a week, including aerobic and muscle-strengthening exercises might improve the health-related physical fitness of adolescents.

Keywords: Exercise; Cardiorespiratory fitness; Muscular fitness; Quality of life; Youths.

RESUMO

Introdução: A avaliação da aptidão física e da qualidade de vida relacionada à saúde (QVRS) em intervenções escolares pode ampliar a compreensão dos efeitos da atividade física (AF) em adolescentes. Objetivo: Analisar os efeitos de uma intervenção de AF na aptidão física e na QVRS em adolescentes brasileiros. Métodos: Alunos de duas escolas secundárias participaram deste ensaio clínico randomizado e foram alocados em grupo intervenção (n = 82) e grupo controle (n = 84). A intervenção ocorreu durante 12 semanas nas aulas de Educação Física, com sessões de 20 minutos compostas por aquecimento, AF estruturada e relaxamento. Foram avaliadas a força de preensão manual, a força de extensão dos joelhos, a potência muscular dos membros inferiores (salto horizontal sem impulso), a aptidão cardiorrespiratória (teste de corrida de vai e vem de 20 m) e a QVRS (KIDSCREEN-10). Resultados: Amostra foi composta por 166 adolescentes (52,5% do gênero feminino; 13,8 ± 0,9 anos). Houve efeitos favoráveis da intervenção no salto horizontal (diferença média: 10,8 cm; IC 95%: 3,3 - 18,3; p = 0,074) e na aptidão cardiorrespiratória (diferença média: 4,5 voltas; IC 95%: 0,2 - 8,2; p = 0,054). Não foram observados efeitos significativos para força de preensão manual, extensão dos joelhos e QVRS. Conclusão: A intervenção de 12 semanas implementada durante as aulas de Educação Física foi eficaz em melhorar a potência muscular dos membros inferiores e a aptidão cardiorrespiratória dos adolescentes. Sessões de exercício de 20 minutos, realizadas duas vezes por semana e compostas por exercícios aeróbicos e de fortalecimento muscular, podem melhorar a aptidão física relacionada à saúde de adolescentes.

Palavras-chave: *Exercício; Aptidão cardiorrespiratória; Aptidão muscular; Qualidade de vida; Jovens.*

Introduction

Regular physical activity (PA) is well-documented to be associated with health benefits among adolescents, such as improvements in cardiorespiratory fitness (CRF)[1]; body composition[2]; metabolic profile[3], bone health[4], and mental health[5]. Thus, given the importance of increasing daily levels of PA in adolescents, schools are an ideal setting to promote it, as they have a wide range of opportunities such as physical education (PE) classes, breaks, extracurricular and classroom activities (active classes)[6].

Similarly, a good level of physical fitness (PF) is considered an important indicator of health in all age groups, including childhood and adolescence[7]. PF is defined as a set of attributes that people have or achieve that are related to their ability to perform physical activities[8] and can be either health- or skill-related, with health-related PF including CRF, muscular fitness (MF), and body composition. CRF and MF have been associated with physical health outcomes (e.g. lower body adiposity and cardiovascular risk factors)[9] and mental health outcomes (e.g. lower depression and anxiety symptoms and higher well-being)[10]. Although some intervention studies have shown significant improvements in CRF and MF in Brazilian adolescents, they did not include a control group to compare the intervention effect[11]. Moreover, evidence suggests that these interventions did not result in significant differences in overall PF among adolescents[12].

In addition to PF, there is growing concern about the need to design school-based PA interventions that address a more holistic view of adolescent health. This includes not only physical outcomes but also social and psychological well-being. One way to achieve this is by incorporating health-related quality of life (HRQoL) as an outcome measure. HRQoL is a multidimensional construct encompassing physical, emotional, psychological, and social domains based on individuals' self-perception, and it has been increasingly studied as an important health indicator in adolescence[13].

Recent literature suggests that PA can positively influence HRQoL in adolescence[14], and the benefits for HRQoL may occur through biological, psychological and social mechanisms[15]. However, findings remain inconsistent[14]. While some intervention studies report significant effects on HRQoL[16,17], others do not[18,19]. These discrepancies highlight the need for further research conducted across diverse geographical and sociocultural contexts.

Although PE lessons provide an important opportunity for adolescents to be engaged in PA[6], they are primarily designed to meet curricular objectives and may not consistently provide sufficient exercise intensity or volume to optimize improvements in PF and HRQoL. Consequently, structured exercise programs implemented during PE lessons have been proposed as a strategy to enhance these outcomes[5,20]. However, despite growing interest in this area, evidence regarding the effectiveness of such interventions remains limited, particularly in low- and middle-income countries, such as Brazil. Additionally, evaluating both PF and HRQoL in school-based interventions may offer a more comprehensive understanding of the impact of PA on adolescent well-being.

Based on this rationale, we hypothesized that a PA program implemented during PE classes would lead to improvements in PF indicators and adolescents' perceived HRQoL compared with their peers in the control group. Therefore, the aim of the present study was to examine the effects of a 12-week PA intervention on PF and HRQoL among Brazilian adolescents.

Methods

Study design and sample

The present study adopted a 12-week randomized controlled trial design, following the Consolidated Standards of Reporting Trials (CONSORT) recommendation[21]. This research represents the second wave of the ActTeens Program, an intervention program designed to improve PA levels in adolescents and was conducted in the school setting during the year of 2023. The study protocol was approved by the human research ethics committee of the State University of Northern Paraná, Brazil (approval number: 4.452.513) and registered at ClinicalTrials.gov (NCT05070377).

Initially, we requested authorization from the Jacarezinho Regional Education Center to carry out the research in secondary schools with students aged 12 to 15 (grades 8th and 9th). After the permission, we contacted the schools directly to explain the research objectives and ask if they agreed to participate in the study. Participants' exclusion criteria were: (I) having a genetic, neoplastic, or mental illness that could interfere with understanding the activity or performance during the research, (II) not taking part in all stages of the study. For this trial, sample size calculation was based on an effect size of 0.10, power of 80%, a 5% significance level, and an assumed correlation of 0.5. Con-

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sidering an assumed attrition of 10%, a minimum of 152 students was required. Five public schools located in the city of Jacarezinho, Paraná (Brazil) were invited, and two agreed to participate in the study. One school was assigned to the intervention group (IG) and the other to the control group (CG). Assuming an average of 25 students per class, three classes from each school were randomly selected by an independent researcher using a computer-generated random number sequence (Figure 1 – Flow diagram). Before starting the study, parents or guardians and students signed the consent and assent forms after being informed about the objectives and procedures of the research. The data were collected at 2-time points (baseline [August 2023] and post-intervention [November 2023]).

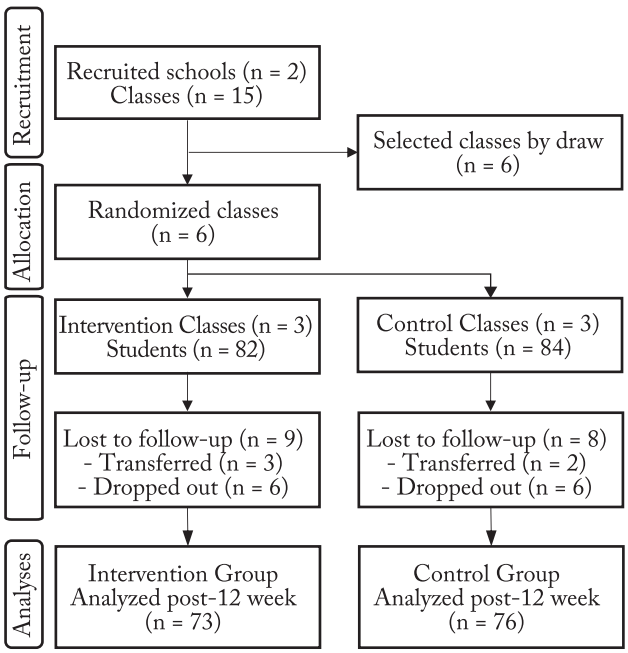

Figure 1 – Flow diagram

Physical activity intervention

The PA intervention included structured PA sessions delivered during PE lessons. The sessions were conducted twice a week over a 12-week period, lasting 20 minutes each. It is important to emphasize that the intervention took place in the first 20 minutes of the PE classes. The structured PA sessions consisted of a combination of muscle-strengthening and aerobic exercise, designed to satisfy participants' basic psychological needs for autonomy, competence, and relatedness. The session followed a specific format including movement-based games and dynamic stretching warm-up (3 minutes); structured PA (15 minutes); and cool-down including static stretching (2 minutes). In each structured PA session, participants were able to choose their own groups (groups of 4-5 students) and were given autonomy to choose the sequence of exercises they would like to perform (4-5 exercises), within a variety of cards, incorporating aerobic exercises (e.g., stationary running, jumping jacks, burpees, lateral shuffle) and resistance exercises (e.g. lateral shoulder raises, bicep curls, triceps extensions, low rows, isometric squat, push-up, among others). The exercise intensity was monitored by heart rate (HR) using a wireless device (Verity Sense, Polar, Kempele, Finland) and tablet (iPad 10th generation, Apple, Cupertino, United States of America). During each session, students were encouraged to maintain their HR above 75% of the maximum estimated for their age.

After the 20-minute structured PA session, students resumed the regular PE lesson conducted by the school PE teacher. The research team did not supervise or modify the remaining class activities, which followed the school's planned curriculum. These lessons generally included sports-based content, encompassing technical instruction, skill practice, and game-based activities. Likewise, students in the CG attended their usual PE classes throughout the intervention period, following the curriculum established by the PE teacher.

Procedures / data collection

All assessments were conducted at the participating schools by research assistants previously trained in earlier interventions, who were blinded to group allocation at all time points (baseline and post-intervention). The research assistants provided a brief verbal description and demonstration of each assessment before the start. Self-report information was assessed using questionnaires. Anthropometric assessments were conducted by two trained researchers. The data collection proceeded as follows: 1) questionnaire with sociodemographic information (e.g., gender and age), PA, and HRQoL; 2) after completing the questionnaires, students went to a private room for anthropometric assessment; and 3) PF tests (i.e., CRF and MF).

Health-related quality of life

HRQoL was measured using the KIDSCREEN-10 questionnaire, which is validated for Brazilian adolescents[22]. The questionnaire is the shortest KIDSCREEN version, which consists of two questions for each of five dimensions: 1) physical well-being, 2) psychological

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well-being, 3) autonomy and parent relation, 4) peers and social support, and 5) school environments. For each item, participants respond using a 5-point Likert scale ranging from 1 (not at all) to 5 (very much). Responses were summed into values of 10 to 50, where a low score indicates a poor HRQoL, and a high score indicates better HRQoL. The KIDSCREEN-10 provides a valid measure of a general HRQoL factor in children and adolescents[23].

Cardiorespiratory fitness

CRF was assessed using the 20-m Progressive Aerobic Cardiovascular Endurance Run (PACER) shuttle run test and administered following standardized procedure[24]. A 20-m course was set up indoors on a hard surface with students instructed to run back and forth between two lines following an accompanying audio file. Test administrators provided verbal encouragement to participants to maximize motivation. The test was ended when the participant failed to complete two consecutive laps within the allotted time or voluntarily dropped out due to fatigue. The total number of laps was registered and used as CRF outcome.

Muscular fitness

Handgrip strength was used as proxy of upper body muscular strength using a handgrip dynamometer (5030J1, Jamar, United States). During each assessment, participants held the dynamometer with the hand and positioned the arm at right angles, with the elbow on the side of the body. When ready, the participant squeezed the dynamometer with maximum isometric effort, which was maintained for approximately five seconds. The average of the best scores (kg) of each hand was used[25]. Lower body muscular power was measured using the standing long jump. Participants should perform a maximal long jump taking off and landing with two feet, simultaneously, from a standing position behind a line marked at zero centimeters. The test was performed twice, with adequate rest between attempts, with the maximal distance jumped in centimeters recorded as the participant's final score[26]. Isometric knee extension strength was measured using a digital dynamometer (FG5100, Lutron/Central Brazil, Taiwan). The participants were instructed to sit in an extension chair with his/her back against the back of the chair and with their knees bent at approximately 90º were instructed to perform maximal isometric knee extension strength until reaching her/his maximum isometric effort. The procedure was repeated twice for each leg. The average of the best scores (kgf) of each leg was adopted.

Confounding variables

Adolescents were asked about their age and gender. PA was assessed by the 'Physical Activity Questionnaire for Adolescents' (PAQ-A), translated and validated for Brazilian adolescents by Guedes and Guedes[27]. Test-retest reproducibility showed an intraclass correlation coefficient between 0.68 and 0.88, internal consistency showed $\alpha = 0.71$ and $\alpha = 0.76$ and moderate correlations with total PA (rho = 0.40; rho = 0.50) and estimated moderate to vigorous PA (rho = 0.48; rho = 0.54) by accelerometer. The PAQ-A is a self-administered tool 7-day recall questionnaire, that assesses participation in different dimensions of PA (i.e., during PE classes, lunch break, after school, in the evenings and at weekends). Each of the 8 questionnaire items is scored between 1 'low' to 5 'high', and a mean score of all items constitutes the overall score, with higher scores representing more active adolescents. Body weight was measured using a portable digital scale (R110, Welmy®, Brazil) with a precision of 0.1 kg, with participants wearing light clothing and no shoes. Height was measured using a portable stadiometer (R110, Welmy®, Brazil). Both body weight and height were measured twice, and the average of the measurements was used. Body mass index (BMI) was calculated using the formula [BMI = weight (kg) / height (m^2)]. Adolescents with BMI values ≥85th percentile were classified as overweight/obese in accordance to age and sex-specific Centers for Disease Control and Prevention growth charts[28].

Statistical analyses

The data obtained were entered into the Excel program and then transferred to the software Statistical Package for the Social Sciences - (Version 20, IBM, New York/United States). The Shapiro-Wilk test was used to verify data normality. General characteristics of the participants were presented as means (standard deviations) for continuous variables, and proportions for the categorical data. The repeated-measures analysis of variance was used to compare the changes in PF and HRQoL at two moments (baseline and post-12week). When Mauchly's sphericity test was violated, the Greenhouse–Geisser correction was assumed. The analyses were adjusted for the following variables: gender, age, and PA. Analysis

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of covariance (ANCOVA) and adjustment for the covariates (gender, age, and PA) and baseline values were employed to compare the effects of interventions on the outcomes between the groups investigated at the post-12 week. In accordance with Vickers and Altman[29], this is an appropriate approach for intervention studies, as it accounts for chance imbalances at baseline between treatment groups. When the F test identified an effect and/or interaction, the Bonferroni post hoc was applied to locate the differences between the means. Effect sizes between groups were calculated using Eta Squared (n^2). The thresholds considered were: small (0.01-0.059); moderate (0.06-0.13); and large (≥ 0.14). The significance level was set at $p < 0.05$.

Results

A total of 166 adolescents aged 12–15 years entered the study (52.5% females; mean age 13.8±0.86 years old). Table 1 presents the baseline characteristics of the participants. Concerning nutritional status by BMI, 16 adolescents (19.5%) in the IG and 18 (21.4%) in the CG were classified as overweight/obese at baseline. Post 12-week, 14 (17.1%) and 19 (22.6%) adolescents were classified as overweight/obese in the IG and CG respectively. After 12 weeks (Table 2) adolescents in the IG increased significantly isometric knee extension strength (mean difference: 1.1 kgf; 95% CI: 0.027, 2.27), standing long jump (mean difference: 14.4 cm; 95% CI: 8.73, 19.99) and CRF (mean difference: 3.8 laps; 95% CI: 1.00, 6.66). However, there were no significant changes in handgrip strength (mean difference: 0.4 kgf; 95% CI: -0.20, 1.09) and HRQoL scores (mean difference: -0.9 score; 95% CI: -2.78, 0.91). For the control group, we found an increase in handgrip strength (mean difference: 0.8 kgf; 95% CI: 0.21, 1.48) and isometric knee extension strength (mean difference: 2.0 kgf; 95% CI: 0.87, 3.06). There were no statistical changes in standing long jump (mean difference: 4.3 cm; 95% CI: -1.36, 9.99), CRF (mean difference: -1.3 laps; 95% CI: -4.11, 1.44) and HRQoL scores (mean

Table 1 – Sample characteristics at baseline.

Variables	Intervention (n = 82) Mean (Standard deviation)	Control (n = 84) Mean (Standard deviation)	p
Age (years)	13.8 (0.9)	13.7 (0.8)	0.317
Weight (kg)	55.1 (13.4)	53.6 (13.8)	0.494
Height (cm)	160.7 (8.0)	160.8 (7.8)	0.956
Body mass index (kg/m^2)	21.2 (4.5)	20.5 (4.5)	0.381
Handgrip strength (kgf)	26.6 (8.3)	26.0 (6.5)	0.635
Knee extension strength (kgf)	26.9 (7.8)	26.6 (8.2)	0.853
Standing long jump (cm)	118.5 (41.6)	116.5 (41.8)	0.780
Cardiorespiratory fitness (laps)	22.2 (12.5)	24.4 (16.9)	0.398
Physical activity (score)	2.9 (1.1)	2.8 (0.9)	0.641
Health-related quality of life (score 10-50)	35.2 (7.5)	34.6 (7.8)	0.429
Females, n (%)	46 (56.1)	43 (51.2)	--

Table 2 – Intragroup comparison between baseline and post 12 weeks of intervention.

	Intervention Group (n = 73)		p	Control Group (n = 76)		p
	Baseline	Post 12-week		Baseline	Post 12-week	
Handgrip strength (kgf)	26.9 (25.2, 28.6)	27.3 (25.6, 29.1)	0.174	26.3 (24.7, 28.0)	27.2 (25.4, 28.9)	0.009*
Knee extension strength (kgf)	26.9 (24.9, 28.8)	28.0 (25.8, 30.2)	0.045*	27.0 (25.1, 28.8)	28.9 (26.8, 31.1)	0.001*
Standing long jump (cm)	117.5 (109.6, 125.3)	131.8 (124.0, 139.6)	<0.001*	114.6 (106.7, 122.5)	118.9 (111.0, 126.8)	0.135
Cardiorespiratory fitness (laps)	21.6 (18.2, 25.1)	25.5 (21.9, 29.0)	0.008*	23.7 (20.3, 27.0)	22.3 (18.9, 25.8)	0.344
Health-related quality of life (score 10-50)	35.2 (33.4, 36.9)	34.2 (32.4, 36.1)	0.318	34.9 (33.2, 36.6)	35.8 (33.9, 37.6)	0.342

Data are expressed as mean and 95% confidence interval; *Significant difference between the moments (baseline compared to 12-weeks) adjusted for the covariates age, gender, physical activity ($p < 0.05$).

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difference: 0.9 score; 95% CI: -0.92, 2.65).

Table 3 shows the intergroup comparisons post-12 weeks after adjusting for the set of covariates (gender, age and PA) as well as baseline values. Significant intervention effects were observed in standing long jump (moderate effect) and CRF (small effect) favorable to IG.

The overall attendance rate during the intervention was 80.1%. HR monitoring showed that participants maintained an average exercise intensity of 65% of peak HR, while the highest recorded values reached 81% of maximum HR, corresponding to an intensity above the moderate range.

Discussion

The current study investigated the effects of a 12-week PA intervention conducted during PE classes of students in grades 8th and 9th in a sample of Brazilian adolescents. The results suggest that the intervention was effective in increasing cardiorespiratory and lower body MF, as hypothesized. However, contrary to our expectations, no significant intervention effects were observed for HRQoL. These results suggest that implementing this intervention in PE classes might confer benefits for adolescents´ PF, without having to add additional sessions or requiring the acquisition of expensive equipment by schools or school boards.

The present study did not observe a positive intervention effect on HRQoL, which is not in line with other school-based interventions[30]. Lubans et al.[31] explore mechanisms to explain the effects of PA on well-being (self-esteem, psychological well-being, quality of life and resilience) in children and adolescents, suggesting that PA can enhance HRQoL. The neurobiological mechanism suggests that engaging in PA enhances the release of endorphins and promoting a sense of psychological well-being. The psychosocial mechanism proposes that PA provides an opportunity for social interaction, improvements in appearance self-perceptions, and independence, which may affect other indicators of well-being. In the present study, it was expected that adolescents would experience increased well-being, beyond the physiological effects caused by practicing PA at moderate/vigorous intensity levels (neurobiological mechanism). In the present study, PA sessions were designed to promote autonomy, competence and relationships (psychosocial mechanism), since they had the autonomy to form groups, and each group member had the opportunity to choose an exercise for the PA session, encouraging relationships and social interaction among peers, which could increase their perception of psychological well-being, however this hypothesis was refuted.

The improvements on adolescents' HRQoL might rely on additional lifestyle adjustments for the beneficial impacts of the interventions to become noticeable. Indeed, HRQoL is a multidimentional construct, and this PE-based intervention was probably not tailored to address some of these dimensions such as relationship with parents. It is plausible that the additional volume in PA could impact physical well-being dimension more than others, but the overall score of HRQoL may require changes in other facets of life. Recent systematic review with meta-analysis showed that physical exercise improves HRQoL in adolescents, however, of the 10 studies included in the meta-analysis, only 2 found a significant effect of the intervention[14], suggesting that increasing PA alone may not be enough to improve HRQoL in apparently healthy adolescents.

Regarding PF, the results showed a significant effect of the intervention on lower limb muscular power and cardiorespiratory fitness. Similar results were observed in previous school-based studies conducted with Brazilian[32], Norwegian[33] and Chinese adolescents[34]. However, these studies present methodological differences that should be pointed out: firstly, they did not use only PE classes to conduct the interventions; secondly,

Table 3 – Effects of the PA intervention on physical fitness indicators and health-related quality of life in Brazilian adolescents.

	Intervention Group vs Control Group Mean difference (95% CI)	η^2	F	p
Handgrip strength (kgf)	-0.37 (-1.3, 0.5)	0.006	0.67	0.414
Knee extension strength (kgf)	-0.83 (-2.4, 0.8)	0.010	1.07	0.302
Standing long jump (cm)	10.8 (3.3, 18.3)	0.074	8.18	0.005*
Cardiorespiratory fitness (laps)	4.5 (0.2, 8.2)	0.054	5.84	0.017*
Health-related quality of life (score 10-50)	-1.6 (-4.0, 0.6)	0.017	2.09	0.150

η^2: Eta Squared – effect size; Data are expressed as mean and 95% confidence interval; *Significant difference between the groups at the post-intervention moment adjusted for the covariates age, gender, physical activity, and baseline values ($p < 0.05$).

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they used strategies to increase PA at breaks, in other subjects beside PE classes and outside the school environment; finally, the duration of the interventions was longer than 12 weeks. The current study only used curricular PE classes (twice a week), with each session lasting 20 minutes to develop the intervention. We believe that two factors were key to the positive results in the PF of these adolescents: the specificity of the exercises performed during the PA sessions and the monitoring of exercise intensity during the sessions by heart rate. For example, the exercises performed during the sessions prioritized muscle strengthening of both lower and upper limbs (e.g. squats, push-ups, shoulder raises, biceps curls, among others) in addition to exercises aimed at improving CRF (e.g. stationary running, jumping rope, jumping jacks, burpees, among others). Furthermore, the HR monitoring allowed the adolescents to maintain a moderate/vigorous intensity, and the teacher gave them feedbacks to encourage them to increase the intensity during the session.

Conversely, the results of the handgrip test did not change following 12 weeks of exercise. Although the intervention employed whole body exercises designed to improve upper and lower body strength, no specific exercises were proposed to improve upper limb isometric strength. This result may be partially explained by the test used to assess upper MF in the current study, which is not specific to the trained muscle group, and then, it may not have been able to detect change. Although significant within-group improvements in handgrip strength and knee extension strength were observed in the control group, no significant between-group differences were found for these outcomes. Therefore, these findings should be interpreted with caution, because the content and intensity of the regular PE lessons were not monitored or standardized by the research team, it is not possible to determine the specific factors responsible for these improvements.

Findings of the present study are valuable, since observational studies have shown that adolescents with better muscular or CRF have lower obesity[35], cardiometabolic biomarkers[36], incidence of mental disorders[37], and higher self-esteem, well-being, and academic performance[38]. Maintaining satisfactory levels of PF during this stage is, therefore, an essential strategy for the early prevention of comorbidities and all-cause mortality throughout life[39]. Investing in school-based interventions focused on PA is more than promoting health in the present, it is a strategic public health action with potential lifelong impact.

Regarding the practical applications of this study, 20-minute sessions twice a week, including aerobic and muscle-strengthening exercises of moderate to vigorous intensity PA, during PE classes, can improve the health-related PF of adolescents, without having to change the planning of the classes and using materials commonly found in the school environment. Strengths of the present study also includes the development of a randomized controlled trial, as well as the monitoring of exercise intensity. Nevertheless, the present study has some limitations that should be acknowledged. First, upper limb strength was assessed using the handgrip strength test, which may not fully reflect adaptations to the muscle groups specifically targeted by the intervention. Second, only two schools were included, and the sample comprised adolescents aged 12–15 years, limiting the generalizability of the findings to other school settings and age groups. Third, the regular PE classes were conducted by the schoolteachers and were neither standardized nor monitored by the research team. Consequently, it was not possible to ensure that the content, exercises, activities, or exercise intensity during the regular PE lessons were comparable between the intervention and control groups, which may have influenced the study outcomes. The findings suggest that a 12-week structured exercise program implemented during PE classes was effective in improving adolescents' CRF and lower-body MF. However, no additional effects were observed for HRQoL. Improvements observed in some PF indicators within the CG suggest that factors other than the intervention may also have contributed to changes over time. Future studies should investigate how the type, frequency, duration, and intensity of PA interventions influence both PF and HRQoL outcomes in adolescents.

Conflict of interest

The authors declare no conflict of interest.

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Author's contributions

Dias PHG: Conceptualization; Methodology; Formal analysis; Investigation; Visualization; Funding acquisition; Writing –

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original draft; Writing – review & editing; Approval of the final version. Santos GC: Conceptualization; Methodology; Formal analysis; Investigation; Supervision; Visualization; Funding acquisition; Writing – review & editing; Approval of the final version. Silva TMS: Conceptualization; Methodology; Investigation; Funding acquisition; Writing – review & editing; Approval of the final version. Silva ELC: Investigation; Writing – review & editing; Approval of the final version. Francisquini MCJ: Conceptualization; Investigation; Funding acquisition; Writing – review & editing; Approval of the final version. Machado-Rodrigues AMC and Costa BGG: Conceptualization; Writing – review & editing; Approval of the final version. Stabelini Neto A: Conceptualization; Methodology; Formal analysis; Supervision; Project administration; Visualization; Writing – review & editing; Approval of the final version.

Declaration regarding the use of artificial intelligence tools in the article writing process

The authors did not use artificial intelligence tools for preparation of the manuscript.

Availability of research data and other materials

After publication, the data will be available upon reasonable request to the corresponding author.

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